University of California
College of Engineering
Department of Electrical Engineering and Computer Sciences

	Problem Set 5	**EE40**
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Reading:

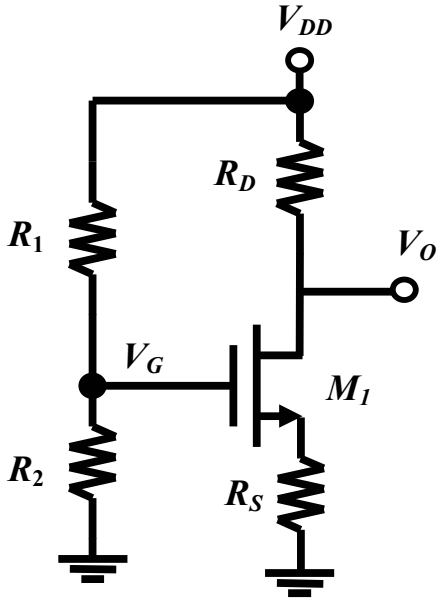
Chap 12.1-12.6 Hambley.
Chap 3.3 of Rabaey

Problems:

Chap 12: 12.15, 12.24, 12.30, 12.37, 12.40, 12.47 (midband refers to the frequencies at which the capacitors are short), 12.51

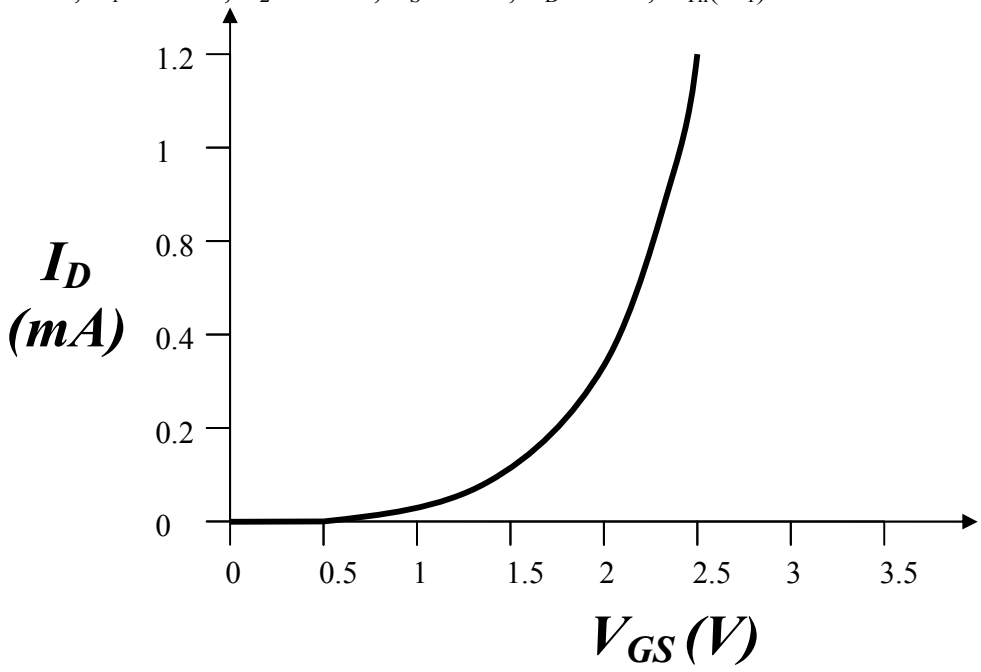
Additional Problems:

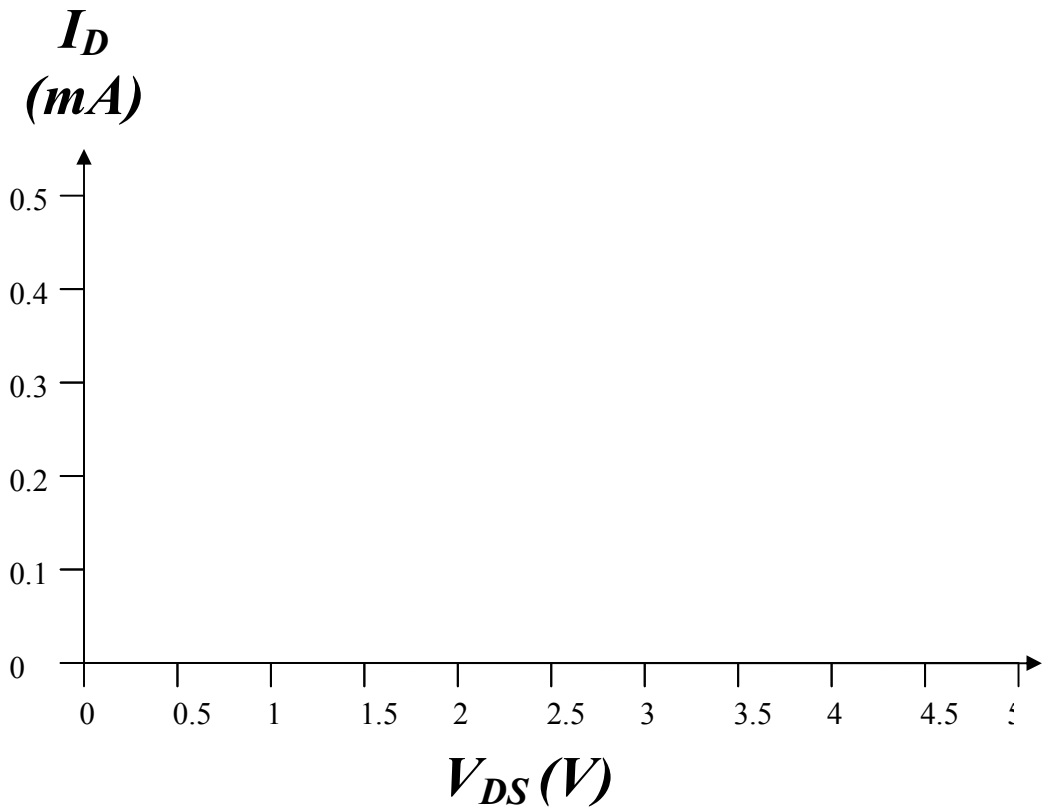
Problem 1



The circuit above has the following parameters:

$V_{DD} = 5V$, $R_1 = 20k\Omega$, $R_2 = 30k\Omega$, $R_S = 1k\Omega$, $R_D = 4k\Omega$, $V_{Th}(M_1) = 0.5V$





a) Find the value of V_G.

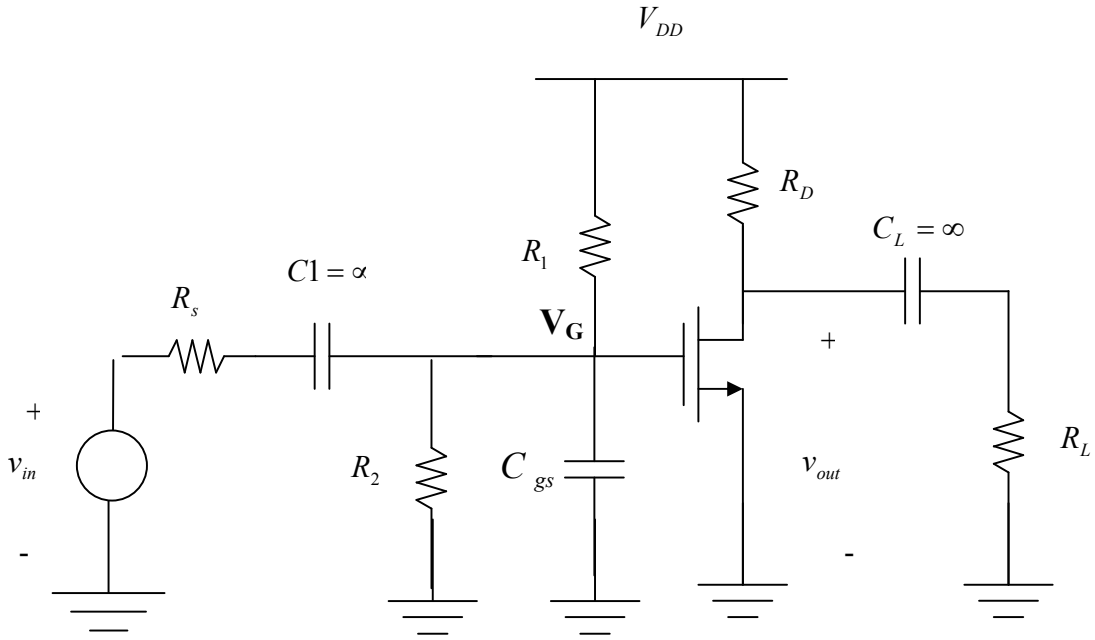
b) From the I_D vs. V_{GS} curve below, find the values of I_{DQ}, V_{GSQ}.
c) From the values of I_{DQ}, V_{GSQ} and V_T, draw the I_D vs. V_{DS} curve for M_1. **Assume $\lambda = 0$**. Annotate V_{GSQ}, I_{DQ} and the point where M_1 enters saturation.

d) From the I_D vs. V_{DS} curve you drew, find the value of V_{DSQ}.

e) Is M_1 in saturation?

f) Find Vo.

Problem 2



Consider the Common Source amplifier above. C_{gs} is the capacitance between the gate and the source of the NMOS.

$V_{DD} = 15\,\text{V}$
$V_{Tn} = 1\ \text{V}$
$\mu_n C_{ox} = 100 \frac{\mu A}{V^2}$
$\frac{W}{L} = 20$
$\lambda = 0$
$R_1 = 4\,\text{M}\Omega \quad R_2 = 1\,\text{M}\Omega \quad R_D = 2K\Omega \quad R_L = 20K\Omega \quad R_s = 10K\Omega$
$C_{gs} = 5\,\text{fF}$ ($1\text{fF} = 10^{-15}$ F)

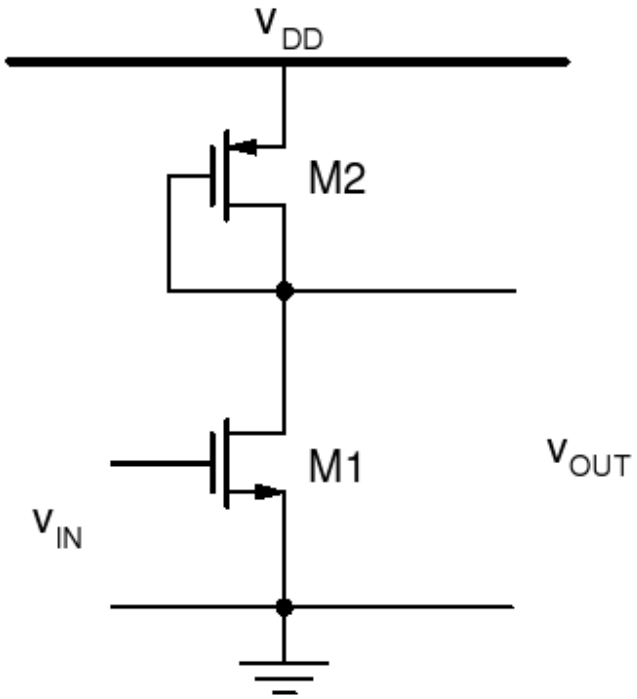
a. What is I_{DSQ} and V_{DSQ}?
Hint: All the capacitors, including C_{gs}, are open circuit for DC analysis.

b. Draw the small signal model for the circuit and find the v_g/v_{in} .

*Hint: All the capacitors **except for** C_{gs} are short circuit for the small signal analysis. **Do** include C_{gs} in your small signal analysis.*

c. Find the small signal transfer function, $\frac{v_{out}}{v_{in}}$. Draw the bode plot for the transfer function.

Problem 3



The circuit shown is biased so that both transistors are in saturation. M1 is an N-MOS and M2 is a P-MOS. The source terminals are indicated by the arrows.

a. Draw the small-signal model of the P-MOS transistor in saturation. (It should be very similar to an N-MOS, differing only by signs). Give expressions for g_{m2} and r_{d2} in terms of the MOSFET parameters and large-signal current.

b. Draw the small-signal model of the whole circuit.

c. Find the voltage gain of this circuit in terms of g_{m1}, g_{m2}, r_{d1}, and r_{d2}.

Problem 4

Find the transfer function of the following amplifier.
Use R1 = 10k, C1 = 0.01uF, R2 = 1k, C2 = 0.001uF, and Gm = 0.01S.